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PRINCIPAL INVESTIGATOR: Tracey Gotthardt

CONTRACTING ORGANIZATION: University of Alaska
Anchorage, Alaska 99501

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Tracey Gotthardt

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Alaska
Anchorage, Alaska 99501

Email: antg@uaa.alaska.edu

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13. Abstract *(Maximum 200 Words)* (abstract should contain no proprietary or confidential information)

The Alaska Natural Heritage Program (AKNHP) provided services to map the extent of habitat spawned upon by sockeye salmon (*Onchorynchus nerka*) in Upper and Lower Sixmile Lakes on Elmendorf Air Force Base (EAFB), Alaska, during summer 2001. The purpose of this project is to provide baseline inventory information on sockeye spawning habitat which may be used to determine the carrying capacity of spawning in this drainage, to plan future limiting habitat studies, and to identify spawning areas for management protection. Project objectives included: locating and georeferencing sockeye salmon spawning areas; calculating potential production of spawning habitat; developing Geographic Information System (GIS) map layer of spawning habitat; mapping 3-dimensional spawning depth profiles; mapping locations of freshwater springs during winter; collecting continuous water temperature data at both spawning and control sites. This is a two-year study, and will be completed in spring 2003. This report summarizes the methodologies used during the 2001 field season and preliminary results are presented.

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INTRODUCTION

The Alaska Natural Heritage Program (AKNHP) proposed to provide services to map the distribution of sockeye salmon (*Onchorynchus nerka*) spawning habitat in Upper and Lower Sixmile Lakes on Elmendorf Air Force Base (EAFB), Alaska, under Contract Award No. DAMD17-01-2-0012. The purpose of this project is to provide baseline inventory information on sockeye spawning habitat which may be used to determine the carrying capacity of spawning in this drainage, to plan future limiting habitat studies, and to identify spawning areas for management protection.

BODY

Project Objectives

In May 2001, AKNHP undertook a project to map the distribution of sockeye spawning habitat in Upper and Lower Sixmile Lakes on Elmendorf Air Force Base, Alaska. The objectives of this project included:

1. Locate sockeye salmon spawning areas for management protection
2. Calculate potential production of spawning habitat
3. Develop Geographic Information System (GIS) map layer of spawning habitat
4. Map 3-dimensional spawning depth profiles
5. Map locations of freshwater springs during winter
6. Collect continuous water temperature data at both spawning and control sites

Upon consultation with Kate Wedermeyer, Base Natural Resource Biologist, we also decided upon additional objectives that would provide information on run timing and salmon age class that were not listed in the original contract. These secondary objectives included:

1. Perform age and length samples on salmon
2. Tag salmon with Peterson Disk tags to gain insight into movements, distribution and timing of spawning

Methods and Preliminary Results

This study was designed to occur over a two-year period, 2001-2002, on Upper and Lower Sixmile Lakes (Figure 1). A Study Plan (**Appendix A**) was developed in May 2001 that would help guide the 2001 and 2002 summer field season's data collection. At the same time, a Safety Plan (**Appendix B**) was developed and implemented.

Habitat Mapping

Gathering data pertinent to mapping lake depth and bottom substrate type was performed during summer 2001. Numbered wooden survey stakes were placed at evenly spaced intervals along the perimeter of both lakes and locations were recorded with a GPS (Figure 2). Depth and substrate type information was gathered at approx. 50 m intervals along transects run in a zigzag pattern between survey stake markers (Figure 2). Data on depth was gathered using the depth meter on a fish finder that was attached to the stern of a canoe or motorboat. Water depth and GPS location was recorded at each 50 m interval along the transect. Depth and location information was then entered into an ArcView GIS database and geographic coverages were created.

Bottom-substrate information was gathered at the same locations as depth data. Substrate analysis was performed by divers visual observation at each sampling location. Refer to **Appendix A** for detailed methods and sampling criteria used to measure and record substrate type. Bottom substrate information was also entered into the GIS database. Future analysis includes applying a krigging algorithm to both the depth and substrate data to produce a surface interpolation for the entire lake area. From this interpolation, finalized depth and substrate maps will be developed. Water depth and substrate type maps will be delivered at the termination of the contract.

Whenever possible, aquatic vegetation samples were collected when substrate type was mostly plant material. We anticipate collecting more vegetation samples during the 2002 summer field season. Plants will be identified to species and this information will be incorporated into the bottom substrate model being developed.

Water Temperature Data Collection
Water temperature was measured using StowAway Tidbit data loggers. Data loggers were buried in bottom substrate and anchored. A small buoy and a length of line was attached to each data logger for visual identification and retrieval purposes (see **Appendix A** for more detailed methodologies). In total, 14 data loggers were deployed during the summer 2001 field season. Two control data loggers were placed in each lake at randomly selected locations. The remaining ten data loggers were deployed and placed in the midst of salmon spawning beds, once the fish had arrived and spawning activity was visible (i.e. redd creation or eggs visible in the gravel). Four data loggers were later found floating around the lake in areas other than where they were deployed and were removed from this years' analysis. In total, 10 data loggers gathered temperature information throughout the spawning season and into the winter (Figure 3). Loggers were removed in early October, temperature information was downloaded, and loggers were replaced in their original lake location. Data loggers will continue to collect water temperature information throughout the next spawning season and winter, and final analysis will be performed in spring 2003 when loggers are finally removed.

Peterson Disk Tagging and Age and Length Samples
Our objective was to tag and gather age and length samples from 200 sockeye salmon, prior to spawning, during the summer 2001 field season. To do so, a sampling station was erected at the weir site (Figure 1). At the sampling station we had a fish measuring board nailed to a table situated in the water behind the weir. Fish were contained at the weir site and passage downstream/upstream was blocked during sampling bouts by blocking off the fish ladder with a small piece of plywood. Once sampling was completed, the fish ladder was re-opened and fish were once again able to pass over the ladder. Fish were captured using dipnets and brought to the sampling table. Fish were placed on the measuring board and fish length and sex was recorded. A scale from the mid-dorsal surface of the left side of the fish was taken and placed on a special adhesive "scale card". Information derived from reading (aging based on the number of rings) the scales will be used for age class analysis. Fish were then gently placed back in the water

and a Peterson Disk tag was attached to the fish with a pin at the front of the dorsal fin close to the body. The fish was then released and allowed to pass through the weir.

In total, 191 sockeye salmon were sampled over a 4-week period, from July 14 –August 10, 2001. Although we attempted to sample throughout the entire run (see **Appendix C** for weir counts and run timing), lack of volunteers to help with sampling and/or missing the fish due to timing conflicts, precluded sampling during the final week of the run. Of the 191 fish sampled, 144 were female, 45 were male, and 1 was not identified to sex. Length measurements were obtained from 186 fish. The mean length was 503.9 cm (±3.15 SE); minimum 400 cm, maximum 610 cm. Scales were taken from 154 of the 191 fish. To date, scales have been pressed in preparation for analysis, but have not yet been read for age determination.

A total of 182 fish were tagged with Peterson disk tags. Fish were tagged with different colored disks depending on the sampling period. The sampling plan (**Appendix A**) called for the use of different color disks per sampling week. However, due to the intensity of the run over a very short time period in 2001 (run peak was July 22-August 1), we altered the tagging schedule to change disk colors over four day increments (as opposed to 7 days). The breakdown of the tagging schedule was as follows:

- July 14 – 21 = 30 tags (Pink)
- July 22 – 26 = 54 tags (Green)
- July 27 – 31 = 50 tags (Yellow)
- August 1 – 5 = 46 tags (White)
- August 6 – 10 = 2 tags (Blue)

Total 182 tags

Tagged fish were identified by visual observation from boat or from shore. Fish location and disk color was recorded on a weekly basis, and this information was plotted into a GIS database. Analysis of this component of the project will be presented in the final report.

Spawning Habitat Assessment

Spawning fish were observed from a canoe or from shore between August 1 – September 9, 2001, and October 2-15, 2001. Spawning only occurred in Upper Sixmile Lake. There was no evidence of spawning in the lower lake. Spawning locations were mapped and habitat characteristics were recorded. The number of fish observed and depth of the spawning area was recorded. Whenever possible, spawning behavior was also recorded (i.e. redd building, egg laying, aggression). This information is currently being digitized and attributed for input into the GIS database.

The PI for this project underwent emergency surgery on September 11, 2001 and subsequent recovery prevented her returning to the study site until October 2. At the same time, EAFB was closed to civilian personnel due to heightened security in the wake of the September 11 attacks. Due to an almost three week absence from the study site, we failed to document peak spawning time. After October 2, 2001 we were able to make a final assessment of spawning areas by boat and using diver observation. At this time, very few fish remained alive, but we were able to document locations where eggs were visible in the gravel. Because we missed the peak of spawning during the 2001 season, we intend to make a concerted effort to be on the spawning grounds more often than proposed during the 2002 summer season.

Spring Mapping

Throughout the course of our investigation we discovered a number of feeder creeks that fed into Upper Sixmile Lake along the southern bank. Outlets of these feeder creeks appeared to be important spawning habitat for sockeye salmon, as spawning fishes were observed at many of these outlets. Water temperatures at these outlets were substantially colder than the lake temperature in general (5.6 to 12.4° C at outlets vs. 13.3 to 17.0 ° C at roadside and central parts of the lake). Feeder creek locations were recorded and entered into the GIS database. A total of 27 feeder creeks were mapped (Figure 4). Data loggers were placed at the base of 4 feeder creeks where spawning was observed. Analysis of water temperature will be conducted when data loggers are removed after the 2002 field season to determine of freshwater input is a significant variable in habitat selection by spawning salmon.

On December 10, 2001 we visited Upper and Lower Sixmile Lake to map spring locations. Due to .5m of fresh snow, we were unable to identify any spring locations. We will revisit the lakes during winter 2002 to attempt spring mapping again.

KEY RESEARCH ACCOMPLISHMENTS

This report summarizes the methodologies utilized during the first year of a two-year study. At this time, data analysis is incomplete and we do not anticipate summarizing results until spring 2003. At that time we will be able to provide a list of key research accomplishments for this study.

REPORTABLE OUTCOMES

To date, no information from this study has been compiled in reportable format. As detailed above, data analysis is incomplete and will require another field season before results and conclusions are available in reportable format.

CONCLUSIONS

The first year of data acquisition provided valuable information to aid in the future design of this study. We will continue to utilize the same survey protocols in 2002 as were used in 2001, with a few exceptions. We plan on spending more time observing and documenting active spawning in 2002. In order to map springs during winter, I suggest several visits to the lakes throughout the course of the winter, at periods when there has been no snowfall for several days. We will also try to get dissolved oxygen (DO) readings at spawning sites during the 2002 season. The DO meter supplied to us by EAFB personnel was not operational during the 2001 season.

It appears that cold-water input into Upper Sixmile Lake may be an important factor in spawning habitat utilization by sockeye salmon. We anticipate that data analysis of water temperature over a two-year time period will provide sufficient information to test this theory statistically.

A total of 4034 sockeye salmon were counted passing into Lower Sixmile Lake at the roadside weir. It is highly likely that a number of other salmon passed through the weir uncounted. This was the second highest escapement (1995 was higher, 4282 fish) of sockeye passing into the Sixmile Lake system over a 13 period (1988-2001). Due to the high volume of fish utilizing what appeared to be rather limited spawning habitat, it was relatively easy to map important spawning areas during the 2001 season. If escapement in 2002 is average, it will be of interest to compare where fish spawn when competition is not as fierce.

Our overall assessment based upon the first year of data collection suggests that in 2001, sockeye salmon did not spawn in Lower Sixmile Lake, although gravel spawning substrate is available in many areas. Most spawning observed in the upper lake occurred along a small portion of the northwest shore, along the roadside and culvert at the west end of the lake, and at various locations along the south shore where there is substantial input from cold water feeder creeks. Each of these spawning areas was characterized by having gravel as the predominant bottom substrate. Many of these areas were very small and patchily distributed along the lakeshore. We cannot state conclusively whether or not spawning habitat is limited in Upper Sixmile Lake without another year of study.

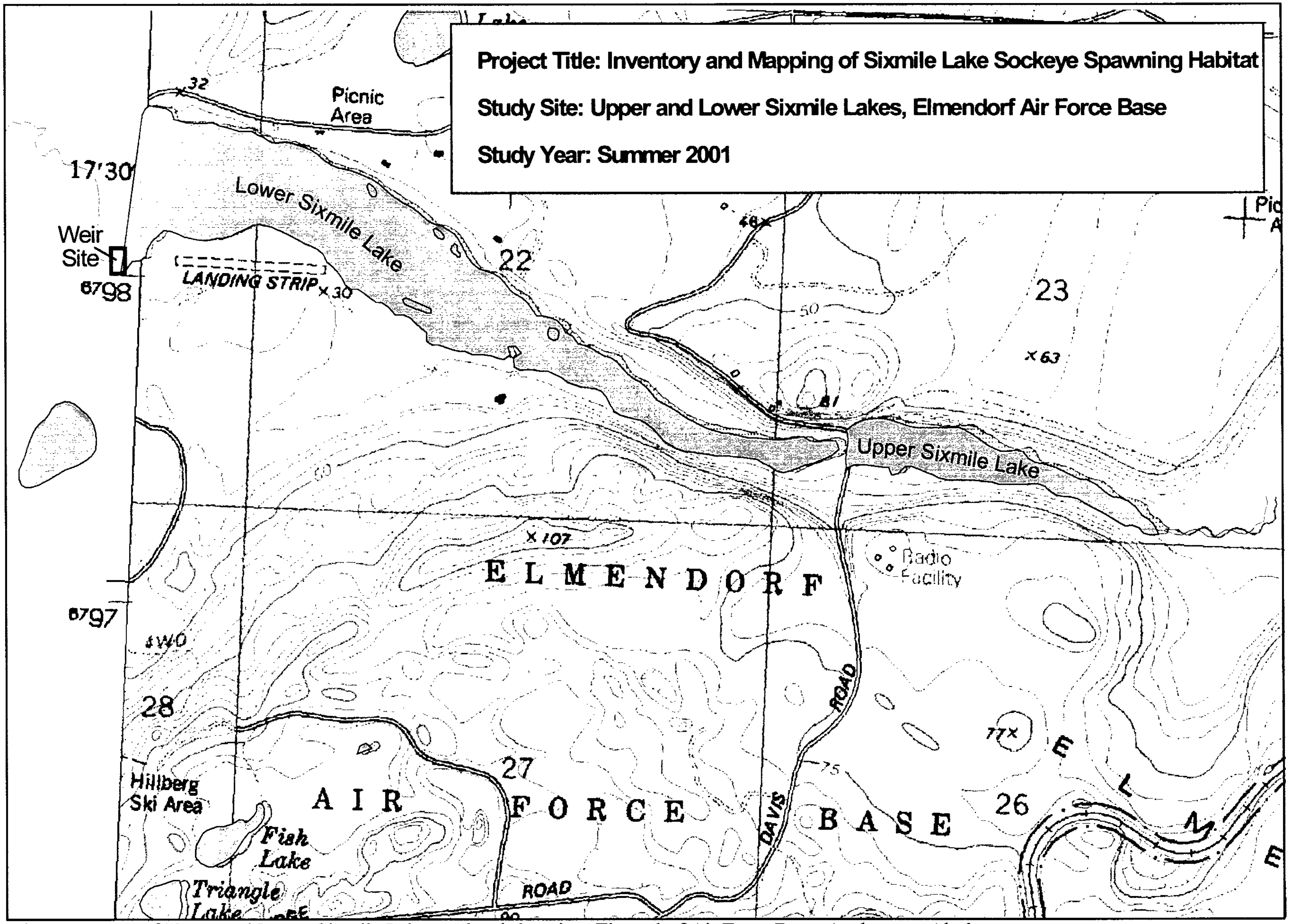

Figure 1. Map of Upper and Lower Sixmile Lakes and weir location, Elmendorf Air Force Base, Anchorage, Alaska.

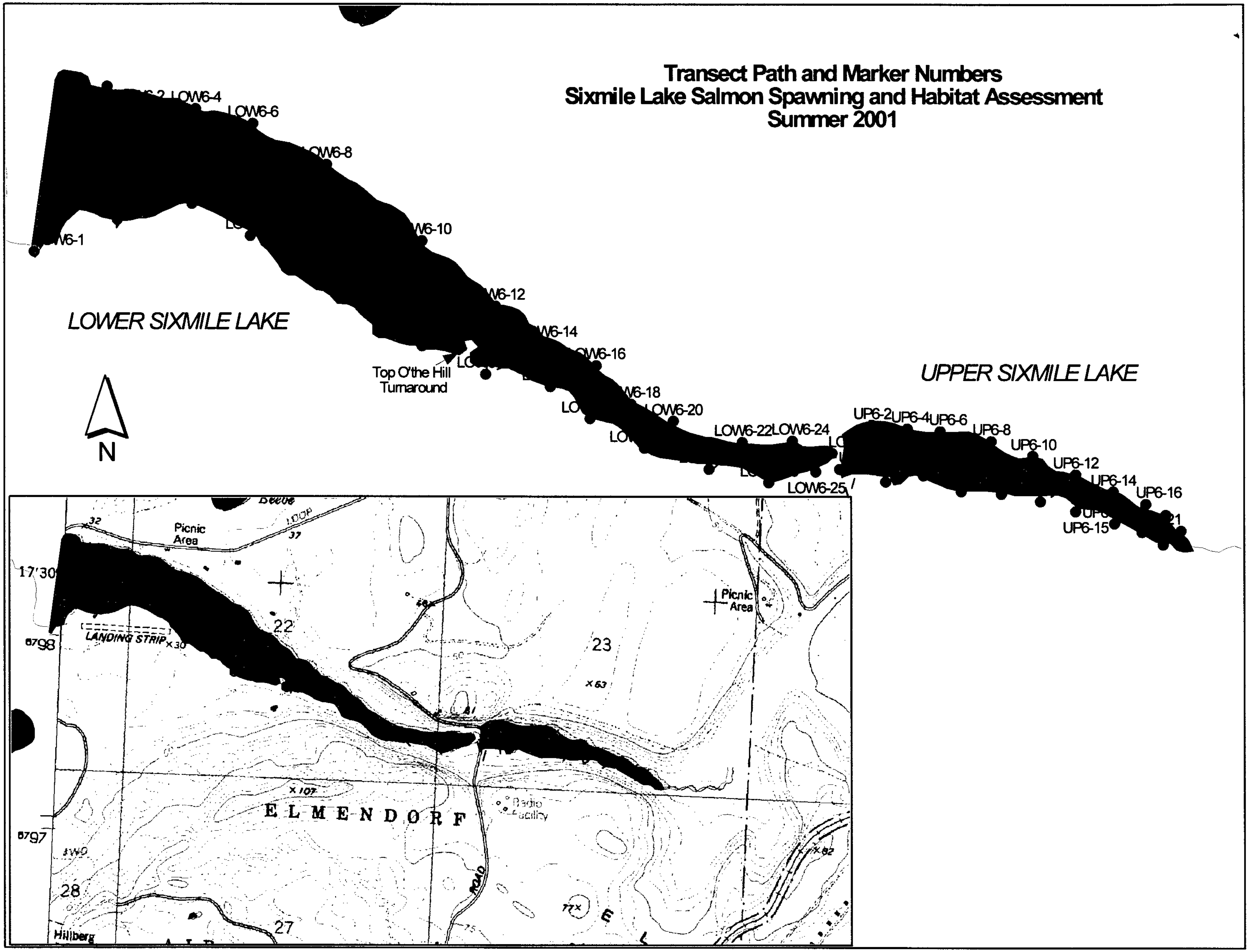

Figure 2. Locations of wooden survey markers and transect path used to collect information on water depth and bottom substrate type.

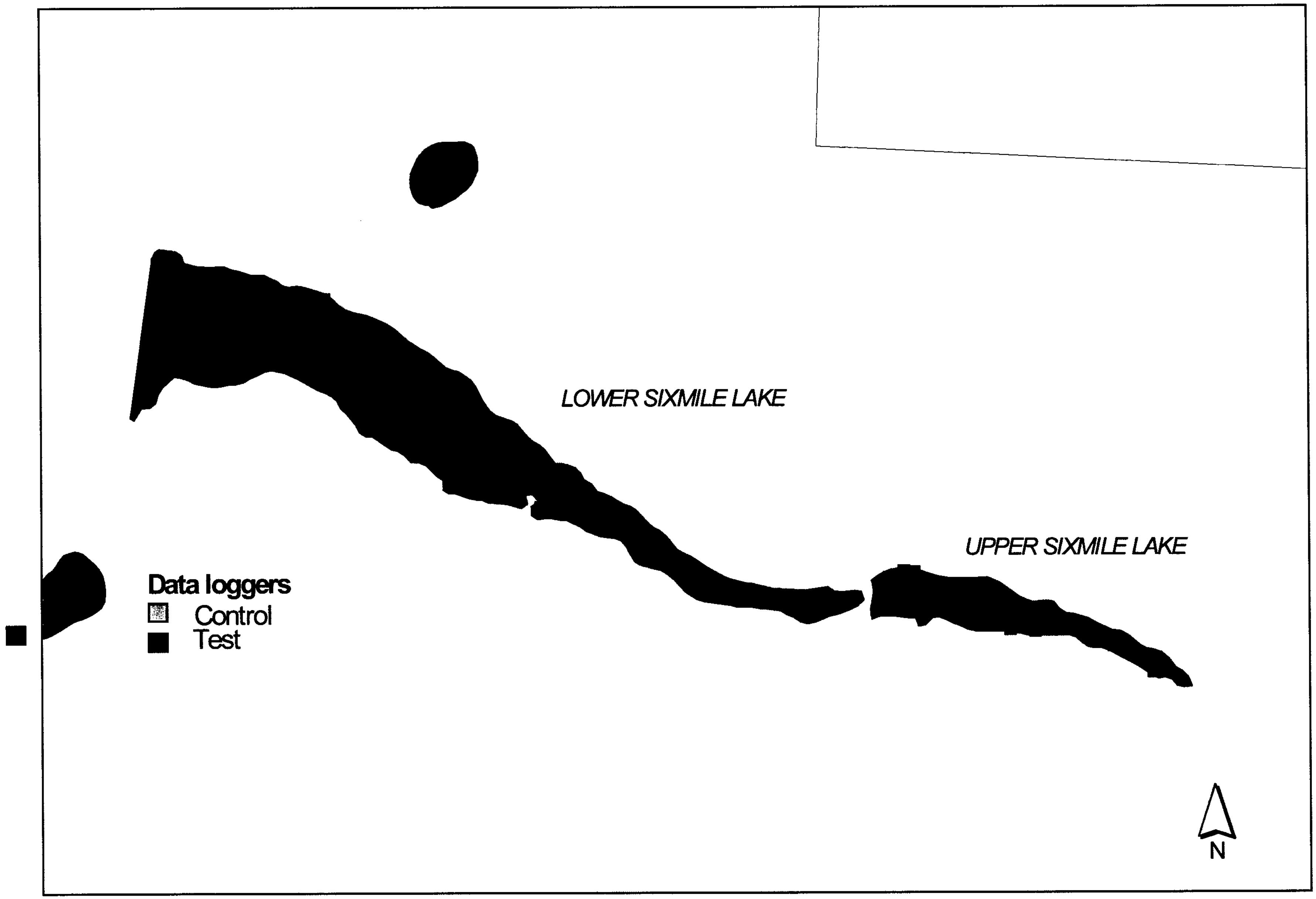

Figure 3. Locations where data loggers were distributed during summer 2001 in Upper and Lower Sixmile Lakes, Elmendorf AFB, Alaska.

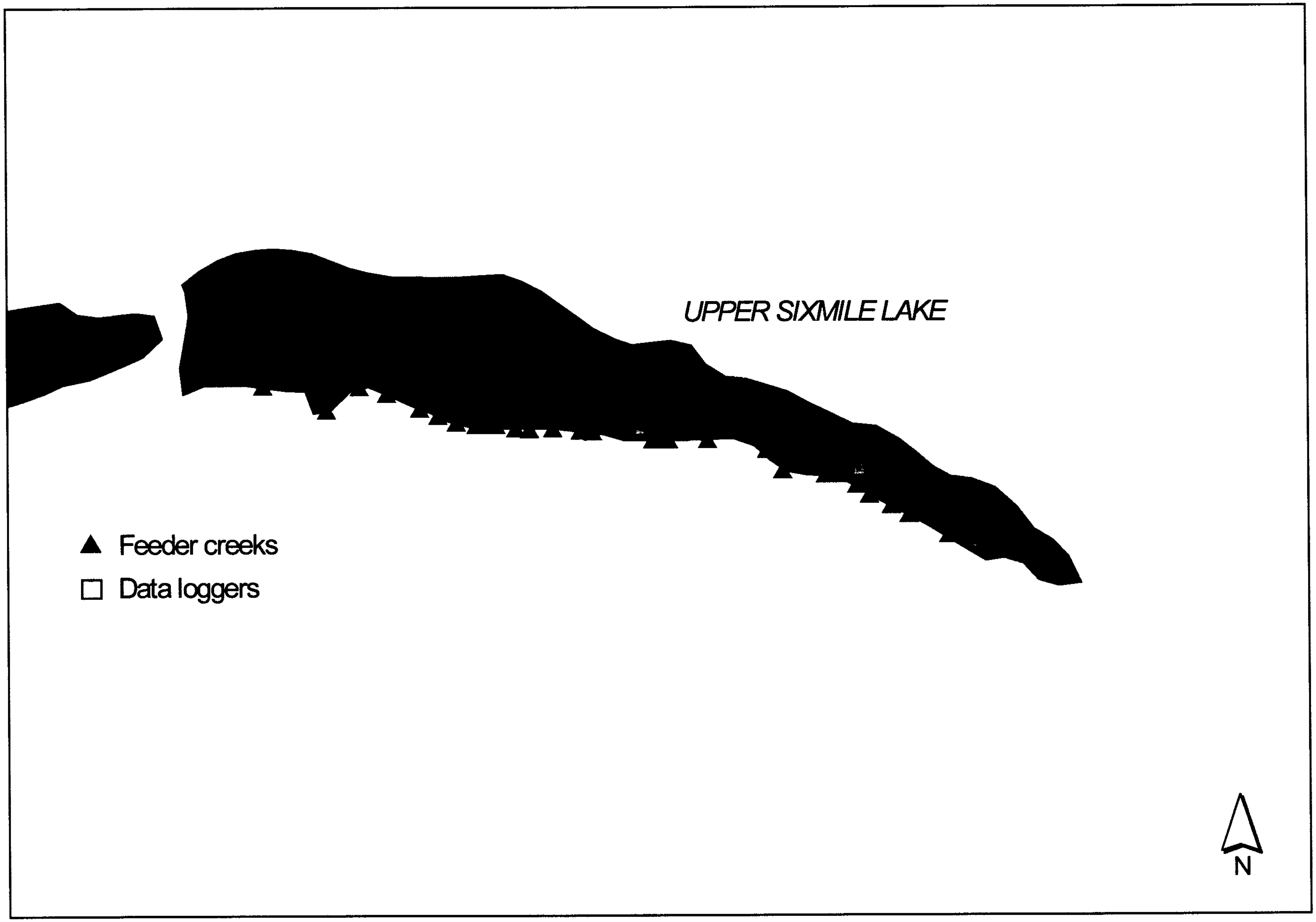

Figure 4. Location of feeder creeks mapped along the southern shore of Upper Sixmile Lake, Elmendorf AFB, summer 2001.

APPENDIX A

Inventory and Mapping of Sixmile Lake Salmon Spawning Habitat

Study Plan 2001-2002

by Tracey Gotthardt (PI)

Determination of lake depth and bottom-type substrates will be conducted during summer 2001. Fresh water spring mapping will occur during winter 2001-2002. All other field components of this project will be conducted during both the 2001 and 2002 summer seasons.

Lake depth

- Establish transect points at systematic intervals
  - Approx. 15-20 transects will be mapped per lake (see Figures 1 and 2)
  - Transect end points will be marked with wooden survey stakes and and recorded using GPS.
  - Surveys for depth and bottom-type will be performed in a zig-zag pattern between end points (see Figures 1 and 2).
- Depth information will be gathered using the depth meter from a fish finder at established points along survey transects. Depth will be measured at approx. 40 m intervals along survey transect lines.

Bottom-substrate/type

- All bottom-typing will be performed by diver visual observation along established transects – no substrates will be removed from the lake for further quantitative measurements.
- Habitat features will be measured at the same point locations that depth readings are taken at.
- Transect survey particle size criteria and codes are based on the Wentworth scale as follows:

Particle size class	Size range (mm)	Size class code
Silt/Sand	< 8	1
Small Spawning Gravel	≥ 8 – 64	2
Large Spawning Gravel	≥ 64 – 128	3
Boulders	≥ 128	4
Bedrock	≥ 1 m^2 (exposed)	5
Other (Clay, peat, organic mat)	≥ 0.5 m	6
Vegetation only	0.0	7

- Divers will carry measurement templates assess bottom substrate type and proportions
  - Proportions will be based on an area $1m^2$ from the data collection.
  - Within the 1 m^2 area we will identify the dominant substrate class and proportions therein.
  - Dominance is defined as an area where more that half the surface area is made up of a single size-class.
  - Size class codes of 1 to 6 (above) are assigned to areas of substrate equal to or greater than 1 square meter that is dominated by a single size class. **Size classes 2 and 3 are most often used by salmonids for spawning.**
  - Particle size is determined by measuring along the longest axis of the particle using a ruler. After some practice, it is often possible to determine the size class of a particle without using a measuring device unless it is near a class boundary. Estimates require checking periodically to ensure accuracy.

Map Coverages – Depth and Bottom-type

- Geographic coverages for depth and bottom-substrate type will be developed by krigging (surface interpolation algorithm) transect survey data using ArcInfo.
- Separate ArcView GIS map coverages will be developed for depth and bottom-type.

Spring Mapping

- Locations of fresh-water springs will be recorded using GPS during winter, when they are visible through the snow.
- Geographic coverages of spring locations will be produced in ArcView.

Water-Temperature

- Water temperature will be measured using StowAway Tidbit data loggers at 14 locations throughout Sixmile Lakes. Four data loggers will be deployed in each lake at randomly selected locations. An additional eight data loggers will be deployed in areas of concentrated spawning activity, for a total of 14 data collection sites.
- Data loggers will be buried in substrate at 30 cm (when possible) and anchored.
- Data-loggers will be attached to a length of line and a small floating buoy so that they may be retrieved periodically and replaced at the same location.
- Data loggers will be retrieved at approx. mid-September, 2001 – downloaded, and then replaced at the same location to collect data throughout the winter, retrieved in spring 2002, downloaded again, then returned for the duration of the 2002 field season, downloaded during fall 2002, replaced, and retrieved in spring 2003..

Spawning Habitat Assessment

- To identify the time of spawning and key spawning areas, the entire lake area will be examined weekly from a boat or canoe, from July 1 till the termination of spawning. Spawning areas (redds) will be recorded using a GPS. Depth at redds and number of fishes present will also be recorded.

- Peak spawning activity will be identified as the time when the greatest number of sockeye are observed spawning or actively defending/utilizing redds.
- Dead sockeye along the shoreline and no further evidence of redds will indicate termination of spawning.
- Redds will be defined based upon three criteria: (1) locations where fine sediment and periphyton have been cleared, (2) locations where adults are observed defending small areas of the bottom, (3) locations where sockeye eggs are observed on the substrate or in the interstices of the substrate (Gipson and Hubert 1993).

Tagging Protocols

- Approximately 200 fish will be tagged in 2001 and again in 2002 with Peterson Disk tags. Each week a different colored disk (tag) will be used to differentiate preferential habitat use based on run timing. The number of fish tagged per week will be approximately proportionate to run-strength based on the10-year average.
    - We anticipate the tagging schedule will closely approximate as follows:
        - Week 1 (Jul. 9 – 15) = 56 tags (Yellow)
        - Week 2 (Jul. 16 – 22) = 56 tags (Green)
        - Week 3 (Jul. 23 – 29) = 56 tags (Pink)
        - Week 4 (Jul. 30 – Aug. 5) = 24 tags (White)
        - Week 5 (Aug. 6 – 12) = 8 tags (Light blue)
        - Total
- Tagged fish will be identified by visual observation from the boat or shore. Fish location and color of Peterson disk will be recorded on a weekly basis in order to determine areas used by fishes prior to, during, and post-spawning.

Literature Cited

Gipson, R.D. and W.A. Hubert. 1993. Spawning-site selection by kokanee along the shoreline of Flaming Gorge Reservoir, Wyoming-Utah. North American Journal of Fisheries Management 13: 375-482.

APPENDIX B

Project Title: Inventory and Mapping of Sixmile Lake Salmon Spawning Habitat

Project Leader: Tracey Gotthardt
Alaska Natural Heritage Program
University of Alaska Anchorage
707 A. Street
Anchorage, AK 99587
(907)257-2782
antg@uaa.alaska.edu

EAFB Contractor: Kate Wedemeyer
Wildlife Biologist
6326 Arctic Warrior Drive
Elmendorf Air Force Base
Alaska 99506-3240

Project Safety Plan

Boating Safety

Each person that will be boating is required to first complete the EAFB Boater's Safety Course. This course covers instruction in preparation, maintenance, trailering and launching, and rules of the road for motorized boats and canoes. This course also provides a brief overview of prevention, recognizing the signs, and treatment of hypothermia.

All starts

1. Check weather forecast
2. Check fuel level (s)
3. Perform periodic maintenance
4. Complete a float plan – file with AKNHP personnel
5. Will notify Kate Wedemeyer whenever we are leaving EAFB for the day. If we should leave after normal office hours we will leave a message on her answering machine and notify gate personnel upon exiting the base.

The operator shall be responsible for inspecting the watercraft prior to its operation to ensure the safety and survival equipment is present, accessible, and in operating condition.

It is the operator's responsibility to ensure the passengers and crew are familiar with the location and fully checked out on the use of the safety equipment aboard.

Boat Trailering

1. Check lights and wiring to make sure they work properly and are undamaged.
2. Make sure trailer tires are inflated to proper pressure.

3. Ensure that all safety straps are secure and in good condition.
4. If there is a safety chain for the boat, make sure it is attached to the boat.
5. Make sure the spare tire is in good condition and inflated to the correct pressure.

Motor
1. Ensure the motor is mounted properly and the clamps are secure.
2. Inspect motor for damaged, missing, or loose parts, including the lower unit and prop.
3. Check fuel and oil lines for proper connection and for any possible leaks.
4. Know the proper operation of the fuel and oil systems.
5. Test run the motor before use and ensure that the pump is pumping water through the motor.

Boat
1. Visually inspect hull, prop, and other equipment on board.
2. Each passenger is required to wear a Coast Guard approved PFD.
3. Ensure that there is always a spare oar, fire extinguisher (applies only to motorized craft), first aid kit, pump (or bucket), and toolbox (equipped with spare pull start and spark plugs) on board.
4. Make sure there is a plug for the boat and that it is in the hole before the boat is put in the water.
5. Make sure there is adequate fuel and oil aboard.
6. Check the anchor for general condition and make sure there is adequate anchor line.
7. Ensure that the battery is charged, in good condition, and firmly secured.
8. Never overload the boat. Evenly disperse the weight.
9. Never let anyone drive the boat that isn't experienced enough too.
10. A cell phone will be carried at all times in case of emergency.

Diving
1. All persons snorkeling/diving will be required to attend a free-dive safety class and pool session given by professional dive instructors. Instruction will include proper diving and snorkeling techniques and will emphasize cold water rescue.
2. All divers will be CPR certified.
3. Divers will be well versed in recognizing early signs and treatment of hypothermia.
4. Dry-suits and other cold water immersion safety equipment must be worn at all times and maintained for optimal performance.
5. All snorkeling/diving will be done on the buddy system – no one gets in the water alone without a person accompanying them with a motorized boat or an observer from shore.
6. Extra clothes and a safety blanket will be carried on board at all times.
7. The accompanying boat will carry a throwable life preserver and a safety line.
8. Whenever a snorkeler/diver is in the water a "diver's flag" and a buoy will accompany them.
9. Each snorkeler/diver will carry a dive knife.

Bear Safety

1. All persons will be required to watch the Bear Safety Training video at EAFB and be well versed in bear safety and avoidance tactics.
2. Personnel will carry pepper spray at all times in the field, even aboard boats.
3. If problem bears are encountered, the EAFB Wildlife Biologist will be contacted of the date, time, and place of such encounters.

APPENDIX C

Sixmile Lake Sockeye Salmon Escapement		
Summer 2001		
Date	**# Sockeye**	**Total**
8-Jul	4	4
10-Jul	1	5
16-Jul	0	5
20-Jul	149	154
21-Jul	133	287
22-Jul	285	572
23-Jul	300	872
24-Jul	1188	2060
25-Jul	405	2465
26-Jul	26	2491
27-Jul	130	2621
28-Jul	286	2907
29-Jul	297	3204
30-Jul	91	3295
31-Jul	305	3600
1-Aug	151	3751
2-Aug	59	3810
3-Aug	45	3855
4-Aug	70	3925
5-Aug	26	3951
6-Aug	11	3962
7-Aug	16	3978
9-Aug	13	3991
11-Aug	9	4000
12-Aug	2	4002
16-Aug	23	4025
18-Aug	4	4029
19-Aug	5	4034
	Total escapement 2001	**4043**